Workshop 2 – Bay-Delta Fishery Resources Comprehensive (Phase 2) Review and Update to the Bay-Delta Plan

California Department of Fish and Game Attachment 1

The Department of Fish and Game (Department) submits the following comments in response to the State Water Resources Control Board's (State Water Board) June 22, 2012 notice which requests scientific and technical information to be discussed in Workshop 2- Bay-Delta Fishery Resources, focused on pelagic fishes and salmonids, as part of the Phase 2 review and update of the *2006 Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary* (Bay-Delta Plan). Our comments highlight and build on recommendations presented in the Department's *Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta* (2010 DFG Flow Report) (CDFG 2010a) and provide additional information and recommendations that the State Water Board should consider in its update to the remainder of the Bay-Delta Plan outside of the Phase 1 review and update as it relates to Bay-Delta fishery resources.

In its first workshop question, the State Water Board asks for new scientific information, the understanding of the certainty or uncertainty regarding this information, and what changes the State Water Board should consider to the Bay-Delta Plan, based on this information, in order to address existing and changing circumstances. The second workshop question asks how the State Water Board should address scientific uncertainty and changing circumstances in updating the Bay-Delta Plan, as well as what kind of adaptive management and collaboration, monitoring, and special studies programs should be considered. Recognizing that these questions are not exclusive of one another and that conflicting issues must be considered when providing recommendations for updates to the Bay-Delta Plan, the Department has prepared the following response which categorizes our recommendations. The first part of our response focuses on providing updated scientific information and recommendations concerning Bay-Delta fisheries, while the second part focuses on water management actions, the importance of habitat and ecosystem functions, adaptive management, climate change, and monitoring and special studies that the State Water Board should consider when updating the Bay-Delta Plan to protect public trust resources.

The mission of the Department is to manage California's diverse fish, wildlife and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. Updating the Bay-Delta Plan is a critical component for guiding adaptive management efforts for fish and aquatic species, and ecosystem restoration projects in the Bay-Delta estuary and its watersheds. As a public trustee, the Department's goal with this response is to provide the State Water Board with information and the rationale for the Department's recommendations for the long-term viability of native fish and the aquatic resources upon which they depend.

Bay-Delta Aquatic Species

Summary of recommendation

The Department has provided the State Water Board with the following information which details the effect of Delta inflow and outflow on Bay-Delta fishes: (1) DFG Exhibit 1 – Effects of Delta Inflow and Outflow on Several Native, Recreational and Commercial Species (CDFG 2010b) as part of the *Informational Proceeding to Develop Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources* before the State Water Board; (2) 2010 DFG Flow Report (CDFG 2010a); and (3) the Department's August 16, 2012 written submission for Workshop 1 – Ecosystem Changes and the Low Salinity Zone (CDFG 2012b). The Department is still supportive of the information and recommendations presented in the 2010 DFG Flow Report (CDFG 2010a). We recognize that the questions identified for this workshop focus on pelagic species and salmonids, however the Department encourages the State Water Board to consider all species in its current review of the Bay-Delta Plan.

Supporting Information

Delta smelt

- At no time should Old and Middle River (OMR) flows be more negative than -5,000 cfs between December and February.
- For critical and dry years, at no time should OMR flows be more negative than -1,500 cfs between March and June.
- Provide low salinity habitat for delta smelt in Suisun Bay by maintaining X2 between 74 km and 81 km between September and November in wet and above normal years.

Delta smelt carry out their entire 1-year lifecycle within the upper estuary, and are potentially affected by Delta flow management at all life stages. The recommendations contained in the 2010 DFG Flow Report (CDFG 2010a) therefore include protective measures throughout the year. The recommended limitations on winter-time (December–February) OMR reverse flows levels are intended to minimize the entrainment of adult delta smelt at the Central Valley Project (CVP) and State Water Project (SWP) water export facilities during their spawning migration. Similarly, the recommended spring (March–June) limitations on OMR reverse flows are intended to minimize the entrainment of larval and juvenile delta smelt. Finally, the recommendations regarding fall X2 (September–November) are intended to ensure adequate quantity and quality of juvenile rearing habitat.

Longfin smelt

- Provide low salinity habitat for longfin smelt in Suisun Bay (and farther downstream) by maintaining X2 between 64 km and 75 km between January and June.
- Depending on year type, provide sufficient water flow to increase abundance of longfin smelt to pre-1987 abundance levels.
- At no time should OMR flows be more negative than -5,000 cfs during the period between December and May.

- During critical and dry years and when longfin Fall Midwater Trawl (FMWT) index is more than 500, OMR flows should be more positive than -1500 cfs during the period between April and May.
- During critical and dry years and when longfin FMWT index is less than 500, OMR flows should be positive during the period between April and May.

The longfin smelt is an anadromous species for which annual juvenile production is strongly, positively correlated with levels of winter-spring outflow and X2 position. The Department's flow recommendations are intended to provide sufficient levels of winter-spring (January–June) outflow, and a sufficiently seaward X2, to ensure annual production levels capable of sustaining and growing the Bay-Delta population. Migrating adult longfin smelt, and their larval offspring, are potentially subject to substantial levels of entrainment at the CVP and SWP water export facilities, particularly in drier years when they tend to be distributed further upstream. The Department has therefore recommended limiting OMR reverse flows during the period between January and June.

Starry flounder

- Provide low salinity habitat for starry flounder in Suisun Bay (and farther downstream) by maintaining X2 between 64 km and 75 km between March and June.
- Depending on year type, provide sufficient water flow to increase abundance of starry flounder to pre-1987 abundance levels.

The starry flounder is a coastal marine species that is reliant on estuarine habitat for juvenile rearing. Starry flounder juvenile abundance within the San Francisco estuary is positively correlated with spring (March–June) outflow levels. The Department's flow recommendations relative to starry flounder are designed to ensure sufficient quantity and quality of brackish water habitat in the estuary, and facilitate movement of early life stages into the estuary.

American shad

- Provide low salinity habitat for American shad in Suisun Bay (and farther downstream) by maintaining X2 between 64 km and 75 km between April and June.

The American shad is a non-native anadromous species. In the Bay-Delta estuary, recruitment is strongly correlated with the magnitude of spring and early summer (April–June). The positive association of flow and recruitment probably has components of adult migrant attraction, larval transport, and the quantity and quality juvenile rearing habitat, particularly the quantity of low salinity zone juvenile habitat. The Department's flow recommendations for American shad are focused on positioning spring X2 to provide sufficient juvenile rearing habitat to sustain the Bay-Delta population.

Bay shrimp

- Create shallow water rearing habitat for bay shrimp in Suisun Bay (and farther downstream) by maintaining X2 between 64 km and 75 km between March and May.

Among the estuarine shrimp species inhabiting the Bay-Delta, *Crangon franciscorum* has the strongest positive response to Delta flows. *C. franciscorum* is an ecologically and commercially important species that is entirely dependent on the estuary, whose juvenile production is positive association with Delta outflow, and a more seaward X2 position in the spring. It is hypothesized that greater Delta outflow increases the size and productivity of brackish water juvenile habitat, and facilitates the movement of juveniles into that habitat. The Department's *C. franciscorum* related flow recommendations are intended to sustain juvenile production, and thus the overall population, at robust levels.

Zooplankton

- Provide low salinity habitat for zooplankton in Suisun Bay (and farther downstream) by maintaining X2 between 64 km and 75 km between January and June.

Two native zooplankton species, the mysid shrimp (*Neomysis mercedis)* and the calanoid copepod (*Eurytemora affinis*), are particularly important in the diet of pelagic fishes such as delta smelt and longfin smelt. Both species have strong positive responses to spring (January–June) Delta outflow. In the case of *E. affinis*, persistence into the summer is an important outflow response. The Department's zooplankton-related flow recommendations are intended sustain zooplankton production for the foodweb benefits provided to key fish species.

Splittail

- To favor Sacramento splittail recruitment, during above normal and wet years, once floodplain inundation has been achieved based on runoff and discharge for 10 days between January and May, maintain continuous inundation for at least 30 days in the Yolo Bypass and at suitable locations in the Sacramento River or in the San Joaquin River.

Splittail spawning and early life stage rearing occurs during the winter-spring period within inundated floodplain and riparian habitats. Annual splittail juvenile production is largely determined by the extent of this habitat, which is in turn determined by the magnitude of winter-spring river flows. The Department's flow recommendations are intended to ensure that in wetter years effective inundation of key floodplain areas is achieved.

Anadromous Fish

The following section summarizes information concerning both green and white sturgeon and salmonids. We have separated these species to better recognize new information pertaining to each of the species and to highlight the importance of providing continued and additional protections with this update of the Bay-Delta Plan. Scientific information regarding sturgeon is still limited enough to preclude the Department from offering specific flow recommendations. However, some life history needs are understood and described below. The Department is still supportive of the information and recommendations presented in our 2010 DFG Flow Report (CDFG 2010a) for salmonids. We encourage the State Water Board to consider these recommendations in the current review of the Bay-Delta Plan.

Green Sturgeon and White Sturgeon

Summary of recommendation

The Department recommends that the following actions be taken as part of updating the Bay-Delta Plan and to determine what future monitoring and special studies might be needed for green and white sturgeon, including:

- Use of a cautionary approach to water management in absence of indices of sturgeon recruitment.
- Identification and subsequent assurance of flows suitable for sturgeon migration, spawning, rearing, and downstream passage in those waters.
- Increase the amount of available spawning habitat for green sturgeon in the Feather River system by addressing fish passage issues.
- Determine sturgeon spawning distribution and success in the Sacramento River between Red Bluff Diversion Dam (RBDD) and Redding.
- Assess the impacts to sturgeon larvae and juveniles at the new pumping plant at RBDD.

Supporting information

The Department submits the following information because: (1) as a public trustee agency, the Department is concerned about the long-term viability of green sturgeon and white sturgeon, (2) the cost to carry out management actions to address green and white sturgeon population declines attributable largely to water operations and flood control, and (3) this information may help the State Water Board weigh beneficial uses.

Flow requirements

The Department's recommendations with regard to flows for sturgeon is limited. Even after several decades of attempting to develop a sturgeon recruitment index, the indices of white sturgeon recruitment appear insensitive to relatively low levels of recruitment and no index of green sturgeon recruitment exists. A more-substantial effort to develop and improve indices of recruitment and use of a cautionary approach to water management in absence of such indices is needed.

Distribution of spawning and rearing

Flows supporting the sturgeon life cycle and migrations are being recognized as an issue in more watersheds. Green sturgeon have been known to widely inhabit the Sacramento River (Moyle 2002). A recent report documents green sturgeon individuals in the Feather River, Yuba River, and the San Joaquin River Basin (DuBois et al. 2011b). Presently there are no scientific publications regarding green sturgeon spawning in these systems, but Department of Water Resources (DWR) biologists have observed spawning in the Feather River (Marty Gingras, CDFG, personal communication, September 19, 2012). USFWS biologists have observed white sturgeon spawning in the San Joaquin River (Marty Gingras, CDFG, personal communication, September 19, 2012), whereas previously spawning there had only been inferred. Understanding and addressing passage issues in these river systems could increase the amount of available spawning habitat for sturgeon. Except under high flow conditions, impediments to upstream passage on the Feather River occur at the Shanghai Bench and at a private diversion structure at

Sunset Pumps. Upstream passage is also impeded on the Yuba River at Daguerre Point Dam. The identification and subsequent assurance of flows suitable for sturgeon migration, spawning, rearing, and downstream passage in these waters is important in supporting the sturgeon life cycle and migrations.

Migrations

Green sturgeon migrations are triggered in part by flows. Unpublished preliminary results from telemetry work by a consortium primarily including DWR, U.S. Bureau of Reclamation (USBR), and UC Davis indicate that (1) adult green sturgeon move rapidly through the system once they leave the ocean and initiate upriver migration, (2) post-spawn downstream migration of green sturgeon adults appears to be closely related to early winter storm events, and (3) some fish exhibit rapid downstream movement in early November with the first major winter flow pulses in the Sacramento River (Marty Gingras, CDFG, personal communication, September 19, 2012). White sturgeon migrations differ somewhat from green sturgeon migrations, but are heavily influenced by flow. The identification and subsequent assurance of flows suitable for sturgeon migration, spawning, rearing, and downstream passage is needed.

Migration impediments and strandings

Spawning migrations are sometimes substantially hindered by water operations and flood control structures, and — because substantial recruitment of sturgeon is uncommon — significant efforts are taken to provide passage. The following two examples demonstrate the substantial on-going efforts to protect migrating sturgeon.

(1) In April of 2011, twenty-four adult green sturgeon stranded in the midst of the spawning run were rescued by personnel from the Department and UC Davis from two flood diversions along the Sacramento River.
(2) Prior to recent re-operation of the RBDD, the dam blocked seasonal (including spawning) movements of sturgeon.

The RBDD gates were permanently raised beginning in September 2011 providing unimpaired passage upstream for sturgeon adults and downstream for juveniles. While investigations such as those described above have occurred in the past to assess the distribution and abundance of green sturgeon, there is no long-term funding in place to sustain a program that would monitor trends except for monitoring green sturgeon spawning on the Feather River, which is conducted by DWR under the terms of a Federal Energy Regulatory Commission hydropower license. The Department recommends long-term funding be established to continue studies in the Sacramento River between RBDD and Redding to determine sturgeon spawning distribution and success. Additionally, given that there are no current established screening criteria for juvenile sturgeon entrainment, and the screens on the new pumping plant that replaced RBDD were designed to meet current salmonid criteria, an assessment of the impacts to sturgeon larvae and juveniles at the new pumping plant is also needed.

Department actions for green sturgeon and white sturgeon

To address sturgeon protection and augment scientific knowledge of sturgeon life stages, the Department is taking action by supporting the adoption of fishing regulations and by seeking research funding. With these actions, the Department seeks to assist the State Water Board in incorporating sturgeon protection into the water quality objectives for the Bay-Delta estuary and its watersheds.

Fishing Regulations for Sturgeon Protection

The California Fish and Game Commission (Commission) has adopted a regulation which prohibits the take or possession of green sturgeon. (Title 14, California Code of Regulations (CCR), section 5.81.) In addition, the Commission has promulgated regulations that set fishing restrictions for white sturgeon. Specifically, the Commission has set a 3-fish per year statewide bag limit and a 46-66 inch size limit for white sturgeon, requires use of a Sturgeon Fishing Report Card, and closed nearly 100 miles of the Sacramento River to white sturgeon fishing. (Title 14, CCR, sections 5.79 and 5.80.) Moreover, since 2007, courts have the authority to issue greater fines for the illegal commercialization of sturgeon (Fish and Game Code 7370). The Department supported the passage of these regulations and statute in response to the infrequent strong recruitment of sturgeon, the ―boom-and-bust‖ character of sport fishing (DuBois et al. 2011), and the impact of flows during the winter and spring on sturgeon populations. If flows more frequently supported greater sturgeon recruitment, the Commission and the Department could allow for more harvest and fishing opportunities.

Research Funding for Recovery Planning

Existing data gaps are identified in the conceptual life history model of green sturgeon Southern Distinct Population Segment as well asthe factors that affect reproduction, growth, and survival in the Sacramento and San Joaquin Rivers and San Francisco Bay-Delta (Israel and Klimley 2008). The Department is currently seeking research funding to address these data gaps to aid the recovery of the species. As these green sturgeon data gaps are addressed, the Department will immediately implement appropriate resource management options that are directly underits responsibility and work with other state and federal entities to improve recovery potentials for green sturgeon.

Salmonids

Summary of recommendation

The Department's biological objectives for salmonids in the Bay-Delta estuary and upstream watersheds as recommended in the 2010 DFG Flow Report (CDFG 2010a) are provided below.

- For the Sacramento River basin, provide sufficient water flow to transport salmon smolts through the Bay-Delta estuary in order to contribute to the attainment of the salmon protection water quality objective[1] of doubling the natural production of Chinook salmon from the average production of 1967-1991.

- For eastside streams that flow to the Bay-Delta estuary including the Mokelumne and Consumes River basins, provide sufficient water flow to transport salmon smolts through the Bay-Delta estuary in order to contribute to the attainment of the salmon protection water quality objective[1] of doubling the natural production of Chinook salmon from the average production of 1967-1991.
- To favor salmon smolts rearing in the Bay-Delta estuary, during above normal and wet years, provide floodplain inundation flows for at least a 10 consecutive day period between January and May, maintain continuous inundation for at least 30 days in the Yolo Bypass and at suitable locations in the Sacramento River or in the San Joaquin River.
- For mainstem rivers that flow into the Bay-Delta estuary and their tributaries, maintain water temperatures and dissolved oxygen at levels that will support adult migration, egg incubation, smolting, and early-year and late-year juvenile rearing at levels that facilitate attainment of specified life-history stage production goals.

In addition, NOAA's National Marine Fisheries Service (NMFS) has developed additional draft recovery actions in the process of developing a final Central Valley Recovery Plan for listed salmonids. A draft Recovery Plan was issued in 2009, entitled *Public draft recovery plan for the evolutionarily significant units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the distinct population segment of Central Valley steelhead* (NMFS 2009b). While the actions are still in draft form and under review by NMFS, the Department and the U.S. Fish and Wildlife Service (USFWS), the report identifies many actions that have direct effects on flow management on the Sacramento River and its tributaries. NMFS plans to release another draft of the Recovery Plan in December 2012. The State Water Board should consider the final Recovery Plan, specifically as identified recovery actions relate to Bay-Delta flows, when updating the Bay-Delta Plan.

[1] Water Quality Control Plan for the San Francisco Bay/
Board Resolution No. 2006-0098. Table 3. Page 14.

Salmon Narrative Objective

Summary of recommendation

The State Water Board should develop objectives that improve inflow and non-flow related habitat conditions for Central Valley Chinook salmon to prevent further decline of the salmon population and to meet the narrative objective for salmon protection in the Bay-Delta Plan.

Supporting information

The 1995 and 2006 Bay-Delta Plans include a narrative objective for salmon protection that states that water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of state law - the California Salmon, Steelhead Trout, and Anadromous Fisheries Program Act, and federal law - the Central Valley Project Improvement Act (CVPIA) (a.k.a. doubling goal). CVPIA directs the Secretary of the Interior to develop and implement,―a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long term basis, at levels not less than twice the average levels attained during the period of 1967-1991,‖ (Section 3406(b)(1) of the CVPIA).

Monitoring of the implementation of water quality objectives, restoration activities, and their contribution to meeting the CVPIA goal of doubling natural production of anadromous salmonids has continued since the adoption of the 1995 Bay-Delta Plan. In tributaries to the Bay-Delta estuary, many agencies are currently working collaboratively to fund and implement projects and conduct monitoring programs to assess progress toward meeting the doubling goal for salmon production. In 2012, the Department completed a comprehensive escapement monitoring plan for Central Valley Chinook salmon which has significantly improved methods for estimating spawning returns (Bergman et al. 2012). This plan, along with the plan developed for steelhead monitoring in the Central Valley in 2010, represent comprehensive, inter-agency efforts to evaluate the status and trends of the runs. The Department encourages the State Water Board to participate in and support these programs.

- **Central Valley Chinook Salmon In-River Escapement Monitoring Plan (Bergman et al. 2012)** – This is a science-based collaborative approach to improve monitoring of adult Chinook salmon returning from the ocean to spawn in Central Valley streams (escapement) and harvested in freshwater. Accurate estimates of escapement are critical to sound management of ocean and inland harvest and monitoring the recovery of listed stocks. Sampling designs were reviewed and recommendations were made for improvement of the field and analytical methods used in the existing programs. The most appropriate survey/monitoring technique (i.e., mark-recapture carcass surveys, redd surveys, snorkel surveys, and fish device counters) was identified for each watershed. To improve data management and reporting, an online database was reorganized and updated to provide a centralized location for sharing Central Valley Chinook salmon escapement estimates and annual monitoring reports.
- **A Comprehensive Monitoring Plan for Steelhead in the California Central Valley (Eilers et al. 2010)** – The goal of this monitoring plan is to provide the data necessary to assess the restoration and recovery of steelhead populations by

determining the distribution, abundance, and population trends of California Central Valley steelhead. The objectives of the plan include: estimate steelhead population abundance with levels of precision; examine trends in steelhead abundance; and identify the current spatial distribution and assess changes. The plan includes recommendations for the development of a centralized database and a coordinated reporting system to be utilized by all Central Valley steelhead monitoring programs.

Since 1995, various programs authorized under the CVPIA and the CALFED Bay-Delta Program, including the Ecosystem Restoration Program which is now administered by the Department in collaboration with the USFWS and NMFS, have provided significant funding for projects, such as fish screens, to restore habitat for and reduce stressors on Central Valley fish and wildlife species.

In addition, several new programs and planning efforts, highlighted below, have been initiated in recent years that will significantly improve monitoring and management of Chinook salmon. The Department encourages the State Water Board to utilize these programs as a resource to gain essential information on naturally spawning and hatchery origin steelhead and Chinook salmon populations migrating through the Bay-Delta estuary.

- **Central Valley Constant Fractional Marking Program** — Initiated in 2007, this program targets the marking/coded-wire tagging of a minimum of 25% of the production releases of fall-run Chinook salmon from Central Valley hatcheries. Data from the first year of complete returns from the program are available (Kormos et al. 2012). Data will be used to improve fall-run Chinook salmon management. Data on hatchery/natural ratios will further refine estimates of natural production of Chinook salmon and therefore will contribute to more accurately monitoring the progress toward meeting the CVPIA doubling goal of natural production.
- **California Hatchery Scientific Review Group** — In 2010, Congress appropriated funds to conduct a scientific review of hatchery programs in California, referred to as the California Hatchery Scientific Review Project. The review included hatchery programs in the Klamath/Trinity and Central Valley basins. The goal of this hatchery program review initiative was to ensure that hatchery programs are managed and operated to meet one or both of the primary purposes for hatcheries: 1) helping recover and conserve naturally spawning salmon and steelhead populations, and 2) supporting sustainable fisheries with little or no deleterious consequence to natural populations. Implementing the recommendations of the review (CHSRG 2012) at the Central Valley hatcheries will assist in reaching the doubling goal by reducing the ecological and genetic impacts of hatchery fish on natural production of Central Valley Chinook salmon. One of the main recommendations of the review report is to transition to onsite releases of all hatchery produced juveniles. It is known that offsite releases via truck transport are a factor that has increased straying within the Central Valley which has contributed to genetic homogeneity among fall-run Chinook salmon. Trucking was instituted to avoid the high mortality experienced by juveniles as they traverse the Bay-Delta estuary. To implement and achieve the goal of transitioning to onsite releases, juvenile survival through the Bay-Delta estuary will need to be increased.

- **NMFS Central Valley Recovery Plan** – In 2009, NMFS completed a draft recovery plan for the Central Valley, for winter and spring-run Chinook salmon and Central Valley steelhead (NMFS 2009b). The plan delineates such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of the listed species. NMFS is now revising the draft plan; a final Plan will be available in the future. Implementation of actions in the recovery plan will contribute to complying with the Bay Delta Plan's narrative objective for the listed salmon species.

Status of meeting the salmon narrative objective

Despite the considerable progress in monitoring, restoration, and management of Central Valley Chinook salmon populations, estimates of natural production in recent years are continuing to fall short meeting the Bay-Delta Plan's narrative objective natural for salmon production. Figures 1–4 show the estimated production of fall, late-fall, winter, and spring-run Chinook salmon in the Central Valley from 1952–2011 relative to the population doubling goals established in the CVPIA (CVPIA graphs from the USFWS Anadromous Fish Restoration Program CHINOOKPROD database 2012). Fall-run Chinook salmon production has varied considerably in recent years, from high levels in 1995 and 2000 to the lowest production over the period of record in 2009 (Figure 1). From 1992 to 2011, the period for measuring progress toward meeting the salmon doubling goal in the CVPIA, fall-run Chinook salmon production has averaged only 360,917 fish compared to the production target of 750,000 fish. Production of late fall-run Chinook salmon has also shown great variation in recent years (Figure 2). Although production in 1998 exceeded the CVPIA doubling goal, average production from the 1992–2011 period was only 17,739 fish compared to the production target of 68,000 fish. The winter-run Chinook salmon population has been at low levels throughout the 1992–2011 period; average production has been only 6,295 fish compared to the doubling target of 110,000 fish (Figure 3). Production of spring-run Chinook salmon has also been highly variable in recent years (Figure 4), but the average production level over the 1992–2011 period (13,560 fish) is far below the doubling target of 68,000 fish.

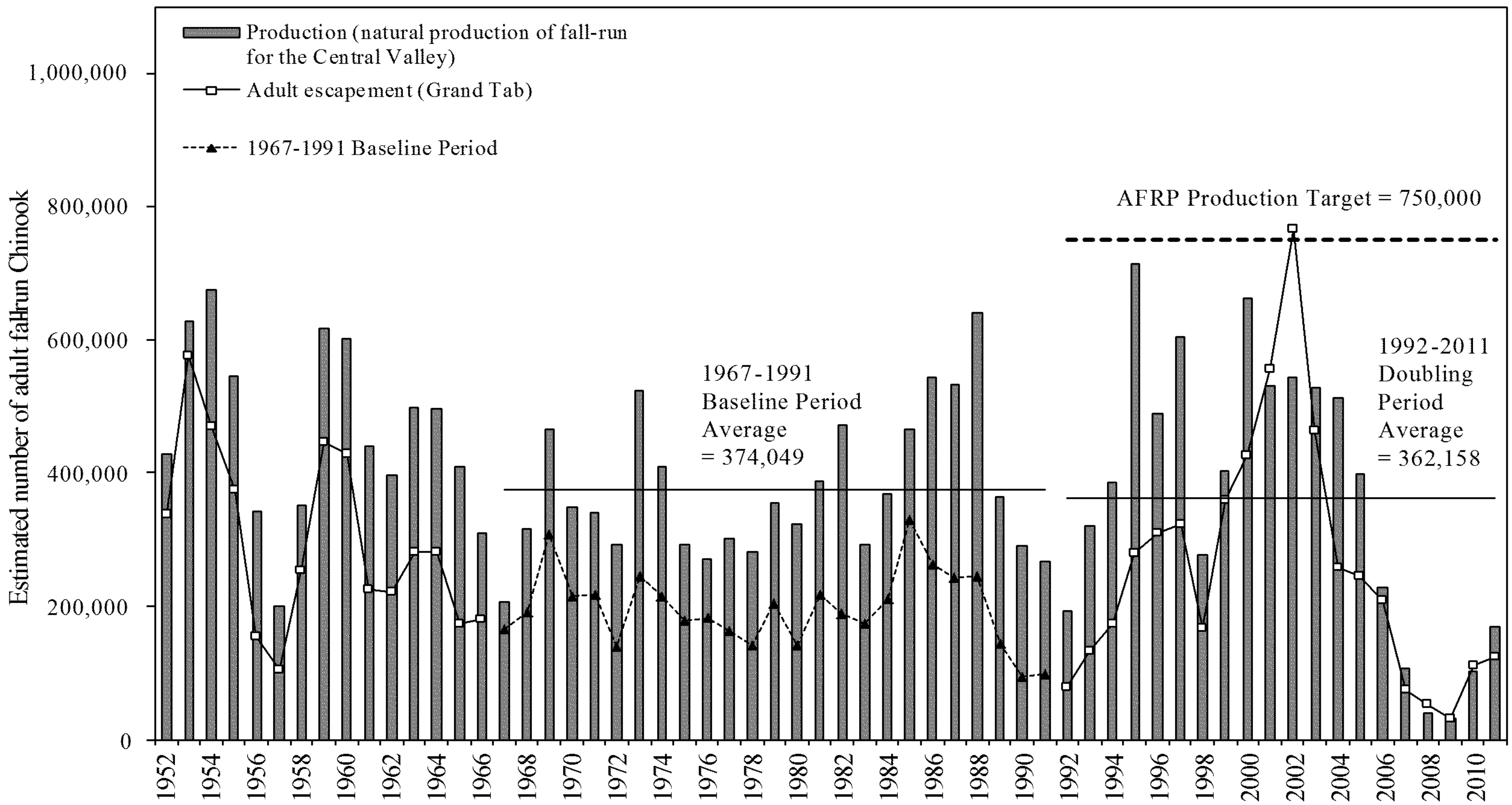

Figure 1. Estimated yearly natural production and in-river escapement of adult fall-run Chinook salmon in the Central Valley rivers and streams. 1952 - 1966 and 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967-1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).

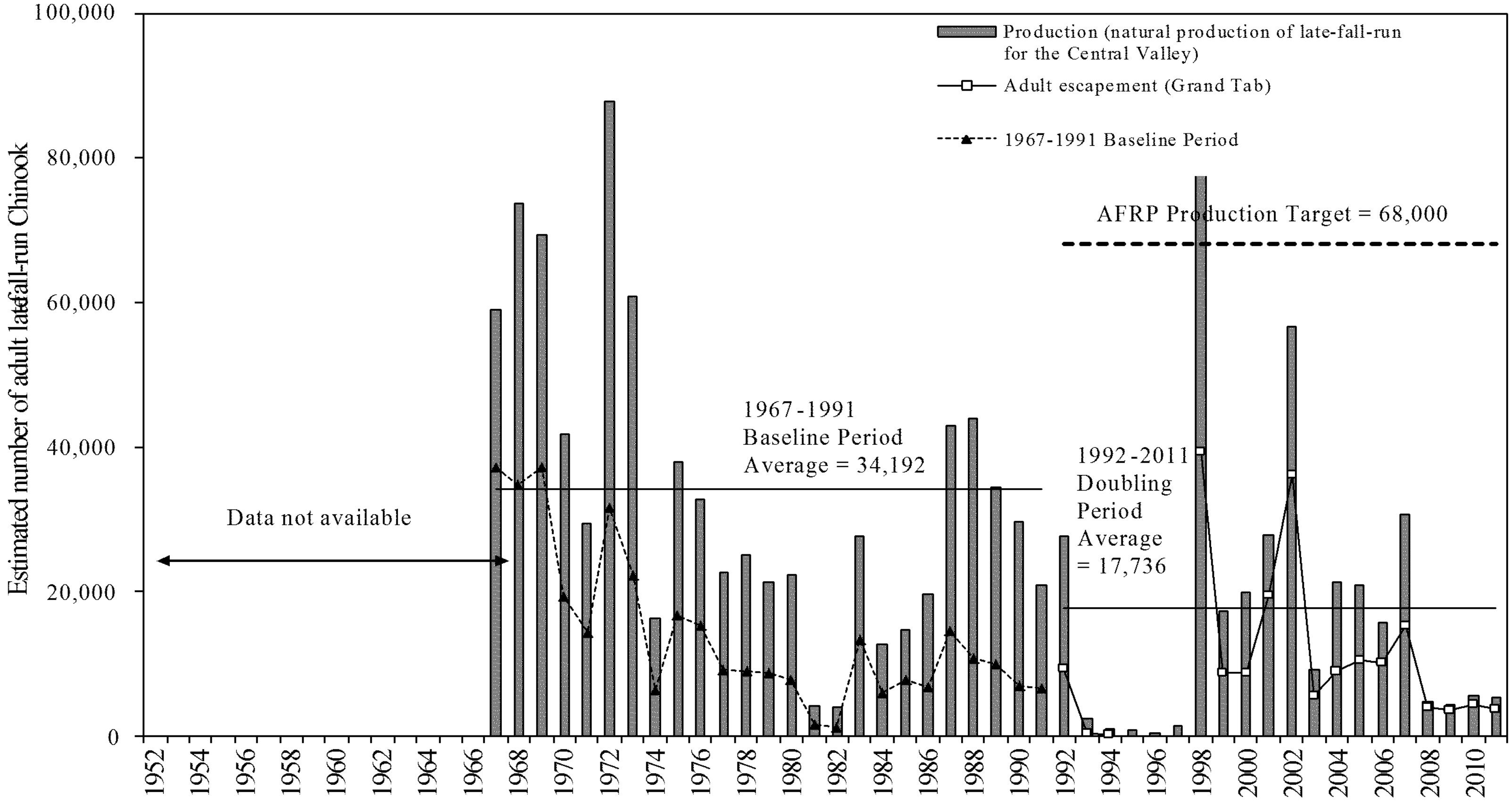

Figure 2. Estimated yearly adult natural production, and in-river adult escapements of late-fall-run Chinook salmon in the Central Valley rivers and streams. 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967-1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).

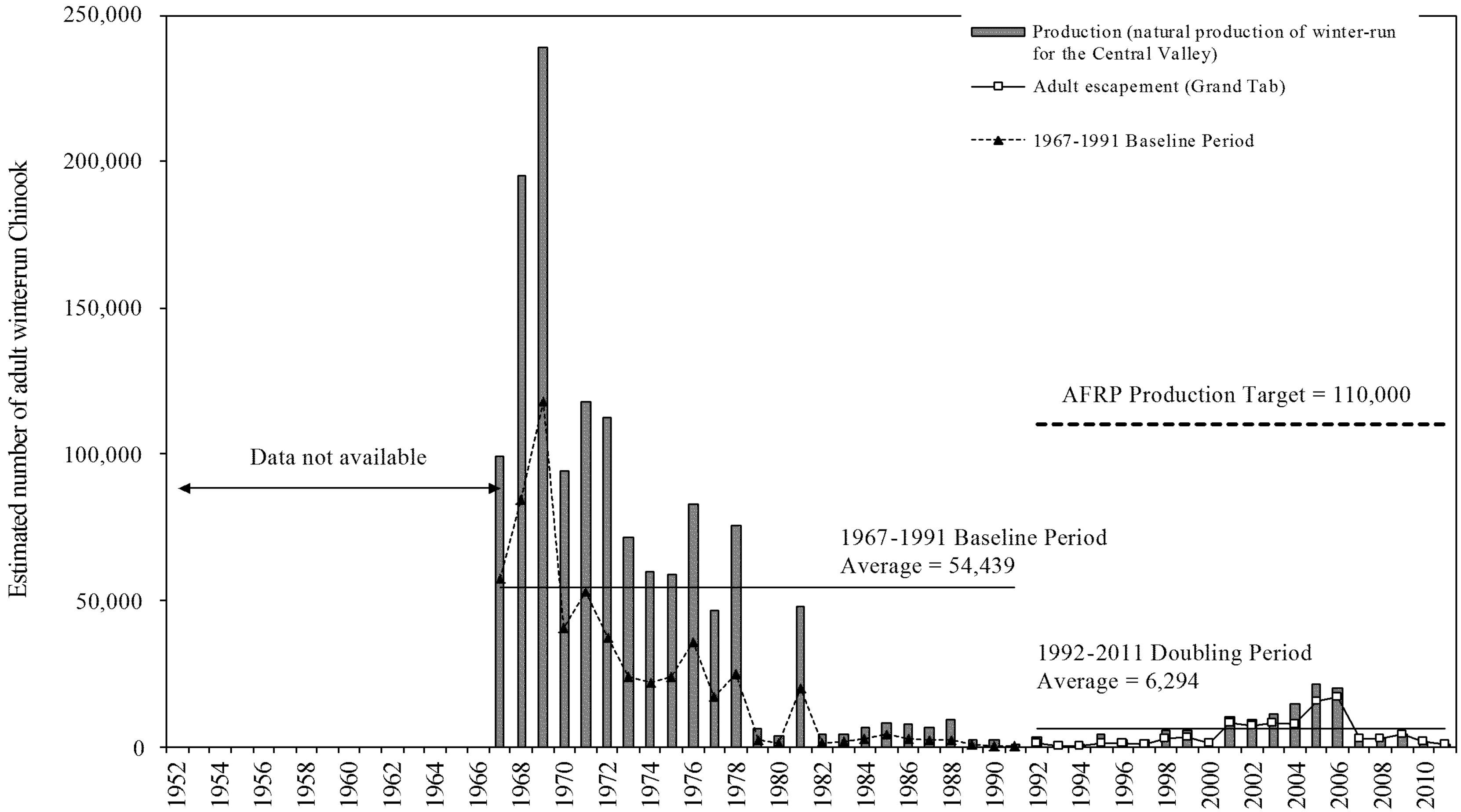

Figure 3. Estimated yearly adult natural production, and in riv er adult escapements of winter -run Chinook salmon in the Central Valley rivers and streams. 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967 -1991 Baseline Period numbers are from Mills and Fisher (CDFG, 1994).

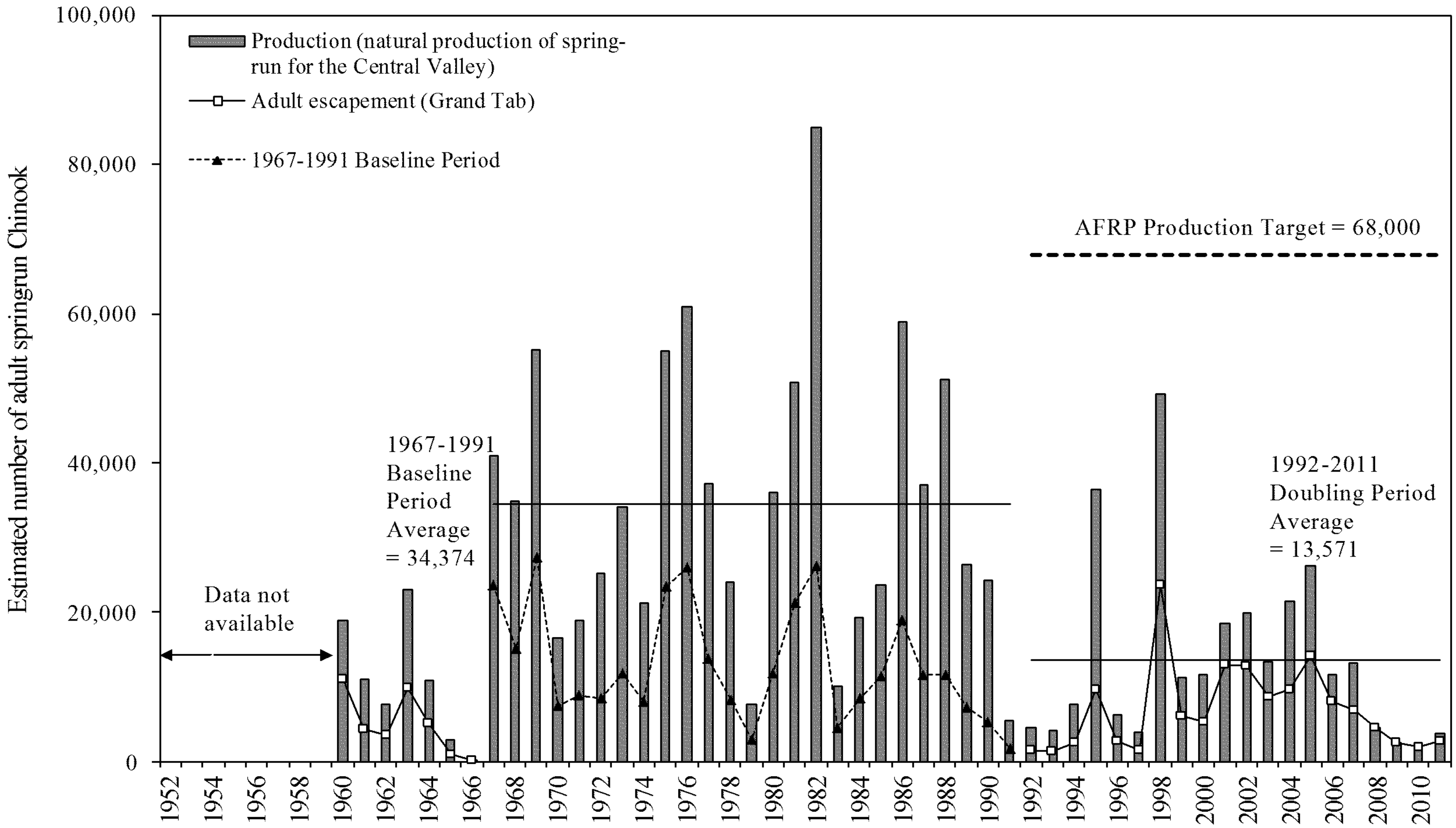

Figure 4. Estimated yearly adult natural production, and in -river adult escapements of spring -run Chinook salmon in the Central Valley rivers and streams. 1960 - 1966 and 1992 - 2011 numbers are from CDFG Grand Tab (Apr 24, 2012). 1967 -1991 Baseline Period number are from Mills and Fisher (CDFG, 1 994).

Delta Cross Channel Gates

Summary of recommendation

The State Water Board should modify the objectives for the Delta Cross Channel (DCC) gate operations in the Bay-Delta Plan to: (1) be based on the operating requirements in the 2009 NMFS Biological Opinion's (BO) Reasonable and Prudent Alternative (RPA), as amended in 2011, for the Operations Criteria and Plan (OCAP) of the State/Federal Water Operations, and (2) include the Department's modification to NMFS's 2009 RPA with 2011 amendments.

Specifically, we urge the State Water Board to consider the recommendations set forth in Table 1. These recommendations are based on NMFS's 2009 RPA and subsequent 2011 amendments, and include modifications made by the Department to allow it to participate in the decision-making process for state-listed species, and to allow for flexible DCC gate closures for up to 14 days for pulse flow experiments in October, which could potentially improve migratory cues for both Sacramento and Mokelumne River origin fall-run Chinook salmon. The Department has found that when it is included in the NMFS decision making process, the results better meet the level of protection the Department requires for state-listed species.

Table 1 California Department of Fish and Game Recommended Delta Cross Channel (DCC) Objectives based on NMFS's 2009 RPA with 2011 amendments. (*CDFG modification in bold italics)*

Date	Action Triggers	Action
October 1 – November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) are greater than 3 fish per day but less than or equal to 5 fish per day.	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	Delta Operations for Salmonids and Sturgeon (DOSS) reviews monitoring data and makes recommendation to NMFS and Water Operations Management Team (WOMT).
	Mokelumne River pulse flow experiment	***DCC gates may be closed for up to 14 days in October, according to design of the pulse flow experiment in the lower Mokelumne River, with prior approval by NMFS and CDFG.***

December 1 – December 14	Water quality criteria are met per D-1641.	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (e.g., Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS ***and CDFG*** prior approval of the study.
	Water quality criteria are not met but both the KLCI and SCI are less than 3 fish per day.	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
	Water quality criteria are not met but either of the KLCI or SCI is greater than 3 fish per day.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT.
December 15 – January 31	Water quality criteria are met per D-1641.	DCC gates closed.
	NMFS ***and CDFG***-approved experiments are being conducted.	Agency sponsoring the experiment may request gate opening for up to five days; NMFS ***and CDFG*** will determine whether opening is consistent with ESA/CESA obligations.
December 15 – January 31	One-time event between December 15 to January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions.	Upon concurrence of NMFS ***and CDFG***, DCC gates may be opened one hour after sunrise to one hour before sunset, for up to 3 days, then return to full closure. USBR and DWR will also reduce Delta exports down to a health and safety level during the period of this action.
February 1 – May 20	Mandatory gate closure.	Gates closed, per current Bay-Delta Plan criteria.
May 21 – June 15	***Gates open.***	***DCC gates may be closed for up to 14 days during this period, if WOMT determines it is necessary.***

Supporting information

The current requirements for operation of the DCC gates, specified in the 2009 NMFS OCAP BO's RPA, as amended in 2011, differ from the requirements in the State Water Board's 2006 Bay-Delta Plan and D-1641 decision. Although the Department recommends a more inclusive and stronger set of objectives for the DCC, at a minimum we recommend that the conditions for DCC gate operation be revised in the Bay-Delta Plan to be consistent with the current operating requirements in the NMFS OCAP BO. Most of the background and justification for the recommendation presented here is excerpted directly from the NMFS OCAP BO (NMFS 2009a), revised in 2011.

The USBR constructed the DCC gates in the early 1950s to redirect high quality Sacramento River water southwards through the channels of the Mokelumne River system towards the South Delta and the CVP pumps at Tracy. This hydromodification prevented the mixing of the Sacramento River water with water in the western Delta, with its higher salinity load, prior to diverting it to the CVP pumps. Originally the gates remained open except during periods of high Sacramento River flow (>20,000 to 25,000 cfs) when scouring of the channel or flooding risks downstream of the gates warranted closure. Currently, USBR operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce saltwater intrusion rates in the western Delta.

The requirements for closing the DCC gates to protect fishery resources were first instituted in the State Water Board's D-1485 decision in 1978. The 1995 Bay-Delta Plan instituted additional operations of the DCC gates for fisheries protection (State Water Resources Control Board 1995). These criteria were reaffirmed in the State Water Board's D-1641 decision. The DCC gates may be closed for up to 45 days between November 1 and January 31 for fishery protection purposes. From February 1 through May 20, the gates are to remain closed for the protection of migrating fish in the Sacramento River. From May 21 through June 15, the gates may be closed for up to 14 days for fishery protection purposes. The USBR determines the timing and duration of the closures after discussion with USFWS, the Department, and NMFS. These discussions occur through the WOMT as part of the weekly review of CVP and SWP operations. WOMT uses input from the Salmon Decision Process to make its gate closure recommendations to USBR.

The Salmon Decision Process includes―Indicators of Sensitive Periods for Salmon‖ such as hydrologic changes, detection of spring-run Chinook salmon or spring-run surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites to trigger the Salmon Decision Process. The Salmon Decision Process is used by the Department, USFWS, and NMFS, and the SWP and CVP operators to facilitate the complex coordination issues surrounding DCC gate operations and the purposes of fishery protection closures, Bay-Delta estuary water quality, and export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Bay-Delta estuary water quality conditions, are used to determine potential DCC closures and export reductions.

The primary route through which emigrating juvenile salmonids in the Sacramento River enter the interior Delta, and hence becoming vulnerable to entrainment by the export facilities, is by diversion into the DCC and Georgiana Slough. Therefore, the operation of the DCC gates may significantly affect the survival of juvenile salmonids emigrating from the Sacramento River basin towards the ocean. Survival in the interior Delta is considerably lower than in the mainstem Sacramento River.

The proportion of juvenile Chinook salmon that enter the Bay-Delta estuary from the Sacramento River is shown in Table 2. The closure of the DCC gate from February 1 through May 20 under the 2006 Bay-Delta Plan protects 100 percent of the fish migrating during this period from entering the DCC channel and entering the Mokelumne River system through Snodgrass Slough. Prior to February 1, the gates can be closed for up to 45 days between November 1 and January 31 (maximum 50 percent). After May 20, the gates can be closed for up to 14 days through June 15.

Table 2 - Proportion of Juvenile Chinook Salmon and Steelhead Production Entering the Bay-Delta Estuary from the Sacramento River by Month.

Month	Sacramento River Total[1]	Fall-Run[2]	Spring-Run[2]	Winter-Run[2]	Sacramento Steelhead[3]
January	12	14	3	17	5
February	9	13	0	19	32
March	26	23	53	37	60
April	9	6	43	1	0
May	12	26	1	0	0
June	0	0	0	0	0
July	0	0	0	0	0
August	4	1	0	0	0
September	4	0	0	0	1
October	6	9	0	0	0
November	9	8	0	03	1
December	11	0	0	24	1

Source: NMFS 2009a. Run determined by length-at-date criteria.
[1] Mid-water trawl data, all runs combined
[2] Sacramento River Basin runs only
[3] Rotary screw trap data from Knights Landing

Prior to the DCC gate closures in February, approximately 44 percent of the annual winter-run juvenile Chinook salmon population is vulnerable to entrainment into the DCC. Emigration of winter-run juvenile Chinook salmon during December and January accounts for nearly all of this entrainment. Loss records from the CVP and SWP fish collection facilities (http://www.usbr.gov/mp/cvo/fishrpt.html) have a slightly lower fraction of the winter-run juvenile Chinook salmon population present in the Bay-Delta estuary during December and January (approximately 21 percent of the annual total), which represents the lag in movement across the Bay-Delta estuary, and fish rearing in the lower Sacramento River and Bay-Delta estuary. The majority of adult winter-run Chinook salmon will migrate upstream through the Bay-Delta estuary during the period when the DCC gates are closed.

Only 3 percent of the annual juvenile spring-run Chinook salmon emigration occurs prior to February in the Sacramento River basin. However, this fraction represents the yearling spring-run life history stage, an important alternative to the more common young of year life history stage where fish emigrate during their first spring after hatching. Spring-run juvenile Chinook salmon are not represented in the salvage and loss records at the CVP and SWP facilities until March and April. Adult spring-run Chinook salmon migrating through the Bay-Delta estuary will encounter the DCC gates in both the closed position prior to May 15 and the open gate configuration after May 15.

Approximately 7 percent of the steelhead from the Sacramento River basin emigrate prior to February in any given year and thus would be vulnerable to open DCC gates and diversion into the interior Delta. Steelhead begin showing up in the salvage at the CVP and SWP fish collection facilities in January and February and most likely represent the steelhead moving out of the Mokelumne system during December and January. Adult steelhead are likely to encounter the DCC gates in both an open and closed configuration throughout their extended spawning migration. Most steelhead have entered the Sacramento system prior to February and therefore would have been exposed to open gates.

The DCC can divert a significant proportion of the Sacramento River flow into the interior Delta. When fully open, the DCC can allow up to 6,000 cubic feet per second of water to pass down the channel into the North and South Forks of the Mokelumne River in the central Delta. During the periods of winter-run Chinook salmon emigration (i.e., September to June) through the lower Sacramento River, approximately 45 percent of the Sacramento River flow (as measured at Freeport) can be diverted into the interior Delta through the DCC and Georgiana Slough when both DCC gates are open. When the gates are closed, approximately 15 to 20 percent (as measured at Freeport) of the Sacramento River flow is diverted down the Georgiana Slough channel. Peak flows through Georgiana Slough can be almost 30 percent of the Sacramento River flows. Together, the DCC and Georgiana Slough can divert nearly half of the Sacramento River's flow into the interior Delta.

In most years, the peak of winter-run Chinook salmon emigration past the DCC occurs from late November through February, based on USFWS trawl and seining data (USFWS 2001, 2003, 2006; Low et al. 2006); when 10 to 25 percent of the Sacramento River flow can be diverted through the DCC and an additional 17 to 20 percent is diverted down Georgiana Slough. Kjelson and Brandes (1989) found that survival of tagged Chinook salmon smolts was negatively correlated ($r=-0.63$) with the percentage of water diverted through the DCC from the Sacramento River. When diversion rates were high (> 60 percent) with the DCC gates open, the survival of smolts released above the DCC was about 50 percent less than those releases which occurred below the DCC. When the gates were closed, there was no difference between the two release points under high flow conditions, however, under low flow conditions, the survival of the upper release point was about 25 percent less than the downstream release point. Kjelson and Brandes (1989) attributed this lower survival rate to the effect of the fish being diverted into Georgiana Slough.

Low et al. (2006) found significant linear relationships between the proportion of Sacramento River flow diverted into the interior Delta in December and January and the proportion of the juvenile winter-run Chinook salmon lost at the CVP and SWP facilities. Analysis of 2-week intervals found highly significant relationships between these proportions in late December (December 15 to 31) and early January (January 1 to 15) periods prior to the mandatory DCC gate closures under the 2006 Bay-Delta Plan.

A series of studies conducted by USBR and United States Geological Survey (Horn and Blake 2004) supports the previous report's conclusion of the importance of the DCC as an avenue for entraining juvenile salmonids into the central Delta. These studies used acoustic tracking of released juvenile Chinook salmon to follow their movements in the vicinity of the DCC under different flows and tidal conditions. The study results indicate that the behavior of the Chinook salmon juveniles increased their exposure to entrainment through both the DCC and Georgiana Slough. Horizontal positioning along the east bank of the river during both the flood and ebb tidal conditions enhanced the probability of entrainment into the two channels. Upstream movement of fish with the flood tide demonstrated that fish could pass the channel mouths on an ebb tide and still be entrained on the subsequent flood tide cycle. In addition, diel movement of fish vertically in the water column exposed more fish at night to entrainment into the DCC than during the day, due to their higher position in the water column and the depth of the lip to the DCC channel mouth (-2.4 meters). The study concluded that juvenile Chinook salmon entrainment at a channel branch will not always be proportional to the average flow entering that branch, and canvary considerably throughout the tidal cycle. Furthermore, secondary circulation patterns can move juveniles into the entrainment zones surrounding a given branch, thus resulting in disproportionately high entrainment rates.

This characteristic was also observed in the recent acoustic tagging studies experiments at the mouth of Sutter and Steamboat sloughs (Burau et al. 2007, Perry and Skalski 2008, Vogel 2008a). The percentage of fish selecting the alternative routes from the mainstem Sacramento River was different than the percentage of water entering the channel, indicating spatial distribution in the channel may play an important role in entrainment rates. Fish that are diverted into the interior Delta and survive the high loss rates migrating through Georgiana Slough and the lower Mokelumne River system are eventually discharged into the San Joaquin River system near RM 22. Changes in Bay-Delta estuary hydrodynamic conditions associated with CVP and SWP export pumping inhibit the function of Delta waterways as migration corridors. When pumping is elevated, the flows in the river reaches surrounding this confluence are directed towards the export facilities, indicated by negative flows in Old and Middle River. Additional loss is experienced during this movement of fish towards the CVP and SWP facilities and throughout the salvage process.

With mandatory closure of the DCC gates from February 1 through May 20 (pursuant to current criteria in the State Water Board's D-1641), approximately 50 percent of juvenile winter-run Chinook salmon outmigration and 70 to 90 percent of the steelhead and spring-run juvenile Chinook salmon migrating downstream in the Sacramento River are not exposed to the open DCC gate configuration and are therefore expected to have a greater likelihood of remaining in the Sacramento River (including Sutter and Steamboat sloughs) and surviving to Chipps Island. These fish will be less vulnerable to entrainment into the interior Delta, where survival is lower due to many factors including loss at the CVP and SWP facilities. The segment of the salmonid populations that migrates before the mandatory closure period will be vulnerable to entrainment through the DCC when the gates are open. All fish will be vulnerable to entrainment into Georgiana Slough, which potentially entrains 15 to 20 percent of the downstream migrants moving past it.

Several years of USFWS fisheries data indicate that the survival of Chinook salmon smolts in Georgiana Slough and the central Delta is significantly reduced when compared to the survival rate for fish that remain in the Sacramento River (Kjelson and Brandes 1989, Brandes and McLain 2001). Data from investigations conducted since 1993 with late fall-run Chinook salmon during December and January are probably the most applicable to emigrating steelhead and spring-run Chinook salmon yearlings due to their comparable sizes. These survival studies were conducted by releasing one group of marked (i.e., coded wire tag and adipose fin clipped) hatchery-produced Chinook salmon juveniles into Georgiana Slough, while a second group was released into the lower Sacramento River. Results have repeatedly shown that survival of juvenile Chinook salmon released directly into the Sacramento River while the DCC gates are closed are, on average, two to eight times greater than survival of those released into the central Delta via Georgiana Slough (CDFG 1998, Newman 2008). More recent acoustic tagging studies support these earlier findings (Perry and Skalski 2008) indicating that when the DCC is closed, survival through the Bay-Delta estuary can increase approximately 50 percent compared to open DCC conditions

(35.1 percent survival with the DCC open versus 54.3 percent survival with the DCC closed; data from Perry and Skalski 2008).

The results of these studies demonstrate that the likelihood of survival of juvenile Chinook salmon, and probably steelhead, is reduced by poor habitat conditions and entrainment encountered in the central Delta. Of those factors affecting survival, water quality parameters, such as temperature, can be significant. Baker et al. (1995) showed that the direct effects of high water temperatures are sufficient to explain a large part (i.e., 50 percent) of smolt mortality in the Bay-Delta estuary. The CVP and SWP export operations are expected to contribute to these poor conditions through altered flow patterns in the Central and South Delta channels. In dry years, flow patterns are altered to a greater degree than in the wet years and are expected to result in a higher level of impact to emigrating steelhead and winter-run and spring-run Chinook salmon smolts (Kjelson and Brandes 1989). If the DCC gates are opened to help meet water quality requirements or other purposes, a significantly greater proportion of Sacramento River flow and juvenile fish will be diverted into the central Delta.

In October, adult fall-run Chinook salmon are moving up through the Bay-Delta estuary toward their natal spawning grounds. Open DCC gates can result in straying of adult salmon as Sacramento River water is routed into the Mokelumne and San Joaquin rivers. Recent studies in the Mokelumne River have shown that a combination of pulse flows along with closure of the DCC gates in October can not only increase the number of Chinook salmon returns, it can also reduce straying of Mokelumne-origin salmon to the lower American River. The following table shows results of these recent studies.

Table 3 - Salmon Returns on the Mokelumne River

Escapement Year	Number of Fall-run Returning	Estimated Stray Rate to American River	Pulse Flow	DCC Closure
2008	412	75%	No	No
2009	2,232	54%	Yes	No
2010	7,196	25%	Yes	Yes (2 day)
2011	18,462	7%	Yes	Yes (10 day)

Redd Dewatering

Summary of recommendation

The Department recommends further study and modeling to identify flows needed in the Upper Sacramento River mainstem to prevent dewatering of steelhead, fall-run and late fall-run Chinook salmon redds. In the interim, a more stable flow management regime from September through March would greatly reduce the risk of dewatering salmonid redds.

Supporting information

Redd dewatering in the mainstem Sacramento River below Keswick Dam can occur as a result of water management operations to meet water quality objectives in the Delta and to meet other competing needs of water, such as irrigation. Reservoir releases from Keswick Dam for the purpose of meeting in-Delta compliance points can complicate upstream fish habitat management activities, such as spawning gravel replenishment in the Sacramento River, which is intended to promote natural salmonid spawning and natural salmonid production. Modeling for various flow objectives could identify or predict the frequency of when mainstem or tributary flows are lacking sufficient flows for certain beneficial uses.

In 2000, Department staff collected data which showed that 18% of the total fall-run Chinook salmon redds in the mainstem Sacramento River below Keswick Dam had been dewatered in December 2000. While this was not a comprehensive study, it should be considered a valuable observation, as it provides detail on the amount of redds that were dewatered in one year. In June 2009, the Anadromous Fish Restoration Project (AFRP) Habitat Restoration Coordinators developed an initial data collection project to address concerns over redd dewatering. In Fall 2010, the AFRP-funded pilot redd dewatering data collection began in conjunction with existing Department and Pacific States Marine Fisheries Commission anadromous fish redd surveys on the upper Sacramento River. Twenty-three redds were classified as dewatered during the survey period. One of the goals of this project is to develop a better coordinated, more efficient, consolidated analysis process that can be used for flow recommendations to protect steelhead, fall-run and late fall-run Chinook salmon redds.

Normally fall-run Chinook salmon begin spawning in the mainstem Sacramento River in large numbers from the first week of October through mid to late November. Late fall-run Chinook salmon spawning begins in early December and peaks in mid-December to mid-January. Therefore, field surveys during the month of October are a good way to document fall-run Chinook salmon redds that are constructed along the stream margins and in riffles. Redd dewatering is typically observed from November through December, but the actual dewatering depends on the dates that the USBR lowers the dam releases (i.e. flows might have been dropped from the October level to a ―new‖ low mid-November level). However, redd dewatering typically does not occur until flows drop from 7,000 to 4,000 cfs. A typical reduction in flow, or ―stepping down‖ of flow, is a flow of 7,000 cfs in early October that is ramped down by 500 cfs in somewhat regular weekly increments to 4,000 cfs flow by mid-November. The Department has observed that in a dry water year, when little water is coming from tributary streams, the redds in the mainstem Sacramento River are more dependent on flows released from Keswick Dam. If flows are maintained at a constant level, there is minimal concern that new redds will become dewatered. However, during water-years in which flows are relatively high early in the spawning season, and are then ―stepped-down‖ as the season progresses, it appears to create conditions that result in higher levels of redd dewatering for naturally spawning fall-run and late fall-run Chinook salmon. Under the current flow reduction regimes, projects to replenish spawning gravel in the river will fail to produce salmon that could contribute to the doubling goal for salmon in the Central Valley.

In August 2012, a Redd Dewatering Report (CVPIA, 2012) outlines the above mentioned data collection and findings, as well as results from surveys conducted in 2011 and 2012. A total of 22 surveys were conducted between 30 November 2011 and 09 February 2012. During that time, 83 redds were marked and recorded as being potentially in danger of becoming dewatered, 12 of which were observed with Chinook salmon present. Out of the 83 redds marked, 25 experienced some form of dewatering; 7 redds were completely dewatered (class 3), 2 were mostly dewatered (class 2) and 16 were ―top of the pile‖ dewatered (class 1).

Linking Flows with Habitat

Throughout the years, the Department and various state and federal agencies have coordinated planning efforts and have worked collaboratively together to implement projects to protect and/or restore functional habitat types that support healthy ecosystems along the Sacramento and San Joaquin rivers and Bay-Delta. Through programs such as the Department's Ecosystem Restoration Program (ERP), the USFWS Anadromous Fish Restoration Program, the DWR Fish Restoration Program Agreement (FRPA), and the DWR FloodSafe Program, efforts have been underway to develop plans and implement actions to restore the ecological health of the aquatic system and improve water management practices, while still addressing the need for adequate flood protection, flow management and levee reinforcement. The following subsections describe habitat concerns in the Bay-Delta estuary and Sacramento River mainstem that are linked to flow.

Bay-Delta Habitats

Summary of recommendation

The Department recommends the State Water Board consider new information about historical habitat types and extent in the Bay-Delta to inform how freshwater inflows can be used and managed to provide ecological functions for species dependent on the Bay-Delta.

Supporting information

A new resource about the historical landscapes of the Bay-Delta has just been published, *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process* (Whipple et al 2012). This historical ecology study was conducted to provide foundational information needed to develop sound large-scale restoration efforts in the Bay-Delta. This research has been performed at the request of the Department and the Ecosystem Restoration Program. This report and accompanying geographic data document early 1800s patterns and processes in the Bay-Delta. The Bay-Delta's historical habitat type extent and distribution are described, the landscape context explored, and driving hydrological and other physical processes examined. The report estimates that approximately 3 percent of the Bay-Delta's historical tidal wetland extent remains today. The report describes three primary Bay-Delta landscapes: the Central Delta, where a freshwater tidal wetland was interwoven with myriad tidal channels; the North Delta, with flood basins lying parallel to the riparian forests of the Sacramento River and its distributaries; and the South Delta, where branching distributary networks supported a broad floodplain that gradually merged with tidal wetlands.

To support the landscape-scale restoration currently taking shape in the Bay-Delta, the information provided in this report should be integrated with contemporary research, monitoring, and ecological theory in order to more explicitly link landscape patterns and processes to ecological functions provided. Efforts are currently underway to address this through a yet to be published study funded by the Department and ERP entitled *Management Tools for Landscape-scale Restoration of Ecological Functions in the Delta* (Grossinger et al. 2011). Tools such as conceptual models, restoration principles, and target metrics will help support the goals of current planning efforts – including the Bay Delta Conservation Plan, the Delta Plan, and the State Water Board's Bay-Delta Plan – to perform large-scale restoration of heterogeneous, interconnected habitats that support native species.

One of the findings and implications of the Whipple 2012 study that is relevant for the State Water Board's consideration of next steps for adaptive management and restoration in the Bay-Delta includes using Delta freshwater inflows to their greatest potential. Historically, freshwater inflows encountered and influenced a much broader range of habitats than they do today. Questions about where water should go are valuable in addition to asking how much water is needed. Understanding the role of hydrology becomes more critical when addressing the current and future challenges related to climate change, such as potentially large floods unknown in recent times related to loss of Sierra Nevada snowpack.

Flood Protection, Floodplain Function, and Habitat Restoration

Summary of recommendation

The Department recommends that the State Water Board consider the following objectives (CDFG 2010a) in regards to floodplain management and function, and operation of bypasses, when addressing flow needs in the Bay-Delta estuary and upstream watersheds:

- Halt species population declines and increase populations of ecologically important native species, as well as species of commercial and recreational importance, by providing sufficient water flow and water quality at appropriate times to promote species life stages that use the Bay-Delta estuary.
- Establish water flows through the Bay-Delta estuary that will likely benefit particular species, community or ecosystem functions in a manner that is: (1) comprehensive, (2) not overly complex, and (3) encourages production. Functional flow criteria shall be established for at least:
    - Yolo Bypass
    - Sacramento River and its basin
    - San Joaquin River and its basin
    - Eastside streams and their basins
    - Interior Delta including Old and Middle rivers
    - Delta outflow
- Establish an adaptive management process to review and modify flow criteria in the Bay-Delta estuary that is:
    - Responsive to advances in scientific knowledge of species natural community and ecosystem needs
    - Responsive to changing environmental conditions including a warming climate, rising sea level, and changes in conveyance and water operations
    - Implemented on a time scale needed to realistically manage desirable species.
- To the extent possible, flow criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes.
- Delta inflows should generally be provided from tributaries to the Delta watershed in proportion to their contribution to unimpaired flow unless otherwise necessary.

In addition, the Department recommends establishing flow objectives for the Sacramento River for the January through August period in order to provide suitable habitat conditions that support the life stages (spawning, rearing, and adult) of native fish species that depend on the Delta and its tributaries.

Supporting information

The 2006 Bay-Delta Plan includes flow objectives for the Sacramento River at Rio Vista for the protection of fish and wildlife beneficial uses from September through December (SWRCB, 2006). These objectives range from 3,000 to 4,500 cfs and are in part intended to provide attraction flows, outmigration flows and suitable habitat conditions for Chinook salmon. However, the 2006 Bay-Delta Plan did not include any specific Sacramento River flow requirements for the remainder of the year, including spring. Flow is the critical factor in maintaining suitable habitat conditions that support the life stages (spawning, rearing, and adult) of native fish species that depend on the Bay-Delta estuary and its tributaries. Flow is the key factor in determining or maintaining water quality factors which affect habitat quality and quantity of both aquatic and terrestrial species. In order to protect and restore natural communities in the Bay-Delta estuary watershed for ecological values such as supporting species, functional habitat types, and ecological processes such as riparian succession, the Department stresses that flow criteria should reflect the frequency, duration, timing, and rate of change of flows, and not just volumes or magnitudes. In addition, Delta inflows should generally be provided from tributaries to the Bay-Delta estuary in proportion to their contribution to unimpaired flow unless otherwise necessary.

Restoring critical components of the flow regime would aid the recovery of at-risk species and help to restore riparian communities that are dependent on natural ecosystem processes such as seasonal flow variability. This includes the need to maintain floodplain function through the process of floodplain inundation. At the same time, levee and bank protection continues to be a high priority for the protection of life and property to those that live along the Sacramento River and the Bay-Delta estuary. Restrictions to the natural flow regime and floodplain inundation due to these manmade structures make habitat restoration and species recovery efforts extremely difficult, and sometimes impossible. Levee systems and stream bank armoring inhibit a number of processes including stream channel meander, bank erosion and sediment deposition that contribute to floodplain creation, which results in altering the character of floodplain habitats.

There have been many flow and floodplain recommendations and stipulations provided to the State Water Board during this process that should be considered when updating the Bay-Delta Plan. For example, one objective from the 2010 DFG Flow Report (CDFG 2010a) recommends that for salmon smolts rearing in the Delta, during wet and above normal years, floodplain inundation flows should be provided for at least a 10 consecutive day period between January and May, and that continuous inundation should be maintained for at least 30 days in the Yolo Bypass and at suitable locations in the Sacramento River or in the San Joaquin River. Floodplains are capable of providing rearing habitat for salmonids that promote enhanced growth and survival relative to mainstream river channels (CDFG 2010c). Increased prey abundance, warmer water temperatures, reduced water velocities, and increased space and cover for predator avoidance have been identified as habitat characteristics that could account for the favorable conditions (Sommer et al. 2001a, b; 2005).

The NMFS BO (NMFS 2009a) stipulates that USBR and DWR, in cooperation with the Department, USFWS, NMFS, and U.S. Army Corps of Engineers, shall, to the maximum extent of their authorities (excluding condemnation authority), provide significantly increased acreage of seasonal floodplain rearing habitat, with biologically appropriate durations and magnitudes, from December through April, in the lower Sacramento River basin, on a return rate of approximately one to three years, depending on water year type (NMFS 2009a).

Similarly, the biological goals and objectives identified in the Department's draft *Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions* (Conservation Strategy) can serve as comprehensive goals and objectives for the environmental resources of the Bay-Delta estuary (CDFG 2011). For example, one of the ERP objectives is to reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional floodplain, riparian, and riverine habitats.

The NMFS Central Valley Recovery Plan (NMFS 2009b) states that floodplains are a vital component of the salmon and steelhead ecosystem and floodplain reclamation and restoration is expected to be a key habitat improvement action that will be necessary to recover these fish. Current DWR flood management planning efforts (the Central Valley Flood Protection Plan (CVFPP) and Conservation Strategy) are using a comprehensive approach in addressing the needs of managing for flood protection while at the same time balancing the effort for ecosystem restoration of the river corridors and Bay-Delta estuary, including the need to maintain floodplain habitats.

Riparian Processes and Regeneration

Summary of recommendation

The Department recommends considering the relationship between flows on the mainstem Sacramento River and riparian processes and regeneration there, and how Bay-Delta estuary flow objectives may influence maintenance of riparian habitat, which is vital to meeting the Department's biological objectives for terrestrial and aquatic species that inhabit this upstream area.

Supporting information

About 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation literally spreading 4 to 5 miles (The Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000-12,000 acres or about 2 percent of historic levels (McGill 1979). Evaluating the relationship between flow management and riparian habitat, along the Sacramento River with comparable habitat on the tributaries, is critical in order to assess habitat needs and population dynamics of riparian-obligate species.

More uniform flows year-round and stream bank armoring have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation (Ayers 2001). The ERP draft Conservation Strategy (CDFG 2011) recommends restoring critical components of the flow regime to aid the recovery of at-risk species and restore natural riparian habitats that are dependent on natural ecosystem processes such as seasonal flow variability. Key limiting factors for cottonwoods (*Populus fremontii*) and other native riparian trees along the Sacramento River include (1) rapid drops in the local water table, often as a result of flow management changes; (2) reductions in the magnitude and frequency of winter overbank flows in the post-dam era, which have likely led to an overall decrease in soil moisture available to riparian plants during the growing season (The Nature Conservancy 2003, Morgan 2005, Morgan and Henderson 2005, Stella 2005, Stillwater Sciences 2006); and (3) a reduced magnitude and altered timing of spring flows, which may have also affected cottonwoods by encouraging recruitment on low elevation depositional surfaces, which are scoured by winter floods or elevated summer base flows. These surfaces then become inundated and scoured by subsequent winter floods or by elevated summer base flows. Flow objectives for the Bay-Delta estuary will have direct bearing on flow management upstream with impacts on riparian regeneration processes in the mainstem Sacramento River below Keswick Dam.

Multi-species Conservation

Summary of recommendation

When considering recommendations and updating the Bay-Delta Plan, the State Water Board should develop a balanced approach that allows for and addresses multi-species conservation. The 2010 DFG Flow Report (CDFG 2010a) recommended several goals that can provide the State Water Board with a useful approach to developing multi-species conservation. Two of those goals have been restated below.

- Integrate all flow measures needed to protect species and ecosystem functions in a manner that is comprehensive, does not double count flows, uses a justified time step, and is documented in peer reviewed or otherwise vetted literature.
- Protect and/or restore natural communities in the Bay-Delta estuary and its watershed for ecological values such as supporting species, functional habitat types, and ecological processes.

Supporting information

There is an emerging body of literature that emphasizes the interconnections between a river's flow regime and the species that have adapted to live within the riverine environment. CALFED's Ecosystem Restoration Program included restoring the variability of the flow regime and associated river processes ―as an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem‖ (CDFG 2011). It is critical to understand how riverine ecosystems are affected by changes in parameters such as the frequency, magnitude, timing, duration, and rate of change of flow in order to make effective management decisions.

Few studies have quantified any of the ecologically critical aspects of the natural flow regime for the Sacramento River. Previously, attention focused only on minimum instream flow and temperature requirements for a subset of salmonid species. Quantifying other aspects of the flow regime, in contrast, would facilitate the formulation of more effective water management and ecosystem restoration strategies. The Sacramento River Flows Study (The Nature Conservancy et al. 2008) was tasked with assessing this. Focal species were selected to represent different habitat ―types‖ and/or uses within the Sacramento River ecosystem and included all of the anadromous salmonids, green sturgeon (*Acipenser medirostris*), bank swallow (*Riparia riparia*), northwestern pond turtle (*Actinemys marmorata marmorata*), and Fremont cottonwood (*Populus fremontii ssp. fremontii*) and certain riverine processes (e.g. river meander). In order to provide a balanced flow regime that meets the needs of all species, habitat types, and natural ecological processes, a multi-species and habitat approach, or using guilds, is required to better ensure that flow management also supports upstream fish and wildlife resources and ecological functions. For example, bank swallows require freshly exposed banks to excavate their nest holes. Historically these exposed banks were the result of high winter flows and natural bank sloughing. Under a more controlled flow regime, high flow events do not occur as frequently or extensively as they did in the past, thereby reducing the amount of nesting habitat. Additionally, conflicts may arise in the timing of flow events to benefit other species. By increasing flows to address temperature requirements for upstream salmonid spawning, swallow nests may be inundated, or bank sloughing may occur, thereby destroying active nests.

Carefully targeted restoration of natural flow characteristics are generally accepted to provide ecological benefits (Poff et al. 1997, Richter et al. 2003). Perhaps the biggest challenge in the practical implementation of ecological flows, from the ecosystem perspective, are the wide range of objectives and focal species that need to be considered. Ecologists and biologists realize that these various objectives cannot all be simultaneously met in any given water year.

Fortunately, flow characteristics that benefit various life history aspects of the targets investigated in the flow study are usually required on a periodic basis and not every single year. In nature, conditions sometimes benefit one target or species to the potential detriment of another in any given year. In managed systems, these trade-offs involve making choices year to year (realizing there will be winners and losers), and being careful to keep track of ―neglected‖ physical process and focal species objectives over time. By not requiring a given set of flow objectives year after year, flexibility is provided to operators and decision makers. For example, it may only be necessary to implement a cottonwood forest recruitment flow every 5 to 10 years, and even then only if one does not occur naturally within that timeframe. Taking advantage of different water year types for achieving different ecosystem objectives is a cost-effective approach and a cornerstone of the Trinity River Restoration Program. For example, above normal and wet years are managed to meet geomorphic objectives, while temperature objectives are the focus in dry and critical dry years. The downside of this flexibility is that water operators will not always be able to rely on fixed rules or an ultimate ecological ―objective function‖. Instead, year to year judgment and an evolving ecological ledger will be needed in order to realize *multiple* focal species benefits.

Adaptive Management and Climate Change

Summary of Recommendation

The recommendation that the Water Board consider the three phase (nine-step) adaptive management framework described in the Final Staff Draft of the Delta Plan (Delta Stewardship Council 2012) and the supporting discussion included in the Department's August 16, 2012 submission for Workshop 1 remain pertinent to Workshop 2. The appropriate time horizons within which the adaptive management phases (or steps) are implemented will depend on the issue being addressed.

Supporting information

Climate change represents a major challenge to the conservation of California's natural resources including the Bay-Delta estuary, and responding to it will necessitate an adaptive management approach. As baseline climatic and physical conditions in the Delta change, habitat and ecosystem services are likely to change, affecting the species that rely on them. For example, alteration of runoff patterns and precipitation, sea level rise, and temperature increases are anticipated to negatively influence habitat suitability for a diverse array of species. Recent modeling studies by Feyrer et al. (2011) and Cloern et al. (2011) have provided additional insights into how such changes are likely to affect habitat quality for delta smelt and Chinook salmon, which will have implications for water management.

Delta smelt

Feyrer et al. (2011) evaluated how abiotic habitat suitability (based on secchi depth and specific conductance) for delta smelt might be affected by changes in outflow due to future development and climate change. The results suggested that each of the development and climate change scenarios evaluated, representing a range of drier and wetter possibilities, would generally lead to further declines in delta smelt habitat across all water year types. Cloern et al. (2011) used modeled water temperatures at Rio Vista to determine the frequency of mean daily water temperatures greater than 25°C (a threshold for high mortality), as a means of assessing the effects of climate change on delta smelt. They found that the frequency of occurrence of temperatures greater that 25°C increases gradually in the moderate warming scenario but rapidly in the fast warming scenario. These predicted declines in habitat suitability are of concern given that Delta smelt primarily exhibit an annual life cycle, have been at record low abundances for several years during the past decade, and have a limited range.

Chinook salmon

In the Central Valley, summer water temperature regularly exceeds salmons' threshold, consequently, each of the Chinook salmon runs (winter, spring, fall, and late-fall) exhibit life history strategies that exploit a spatial and temporal window of opportunity with respect to suitable temperatures for migration, holding, spawning and rearing (National Research Council 2012). Construction of dams and other human development resulted in a reduction in the extent of available habitat and significantly reduced the limited windows of opportunity that historically existed (National Research Council 2012). Cold water pool storage and reservoir operations now play an important role in managing water temperatures below the dams in order to support salmon. The anticipated changes in runoff pattern and precipitation associated with climate change could effect reservoir operations as a result of reduced storage opportunities, less year-to-year carryover storage, and less water for cold water releases during hot summer months (USBR 2011, National Research Council 2012) further exacerbating existing habitat constraints and conflicts associated with the allocation of water.

To assess the effects of climate change on winter-run Chinook salmon, Cloern et al. (2011) compared projected mean monthly water temperatures of the Sacramento River at Balls Ferry for the period of May-October against a threshold of 16°C (a threshold for high mortality of eggs and pre-emergent fry). They found that frequency of occurrence of lethal temperatures for winter-run Chinook salmon (>16°C) grows modestly in the moderate warming scenario, except during the simulated drought of the 2070-decade when this threshold is exceeded in 17 months, while river temperatures greater than 16°C become common (>20 months per decade) after 2080 in the fast warming scenario. The projected increases in river temperature are of great concern for winter-run Chinook salmon , given that their spawning is timed such that eggs develop in summer and the extent of their spawning habitat is so highly constrained. However, if predictions of warmer and longer summers and shifts in precipitation come to fruition, the windows of opportunities for the other runs will narrow, as well, and some will eventually close (National Research Council 2012).

Monitoring and Special Studies

Implicit in the adaptive management framework is the expectation that the consequences of management actions will be monitored and assessed to determine whether and how such actions are having the intended effects. Therefore, it will be critical to monitor the implementation of the updated water quality objectives to assess how the ecosystem responds to these management interventions.

Summary of Recommendations

The Department provides the following information and recommendations for the State Water Board's consideration during the review and update of the Monitoring and Special Studies Program.

Bay-Delta Aquatic Species

In its comments to the State Water Board concerning the Supplemental Notice of Preparation and Notice of Scoping Meeting for the Comprehensive Review, dated May 2, 2012 (CDFG 2012a), the Department identified a number of potential changes to the existing Monitoring and Special Studies Program that should be considered during this process, which are summarized below:

- The State Water Board should consider focused extensions of existing studies, such as the Summer Townet Survey, Fall Midwater Trawl Survey, Spring Kodiak Trawl Survey, crustacean and lower trophic level surveys (e.g., zooplankton), in order to generate the information necessary to more fully understand the effects and efficacy of outflow, export and inflow objectives. For example, the Department recommends expanding surveys into Cache Slough and the Sacramento Deep Water Ship Channel, in order to provide baseline data for these regions prior to planned large-scale habitat restoration and better information on the distribution and habitat of delta smelt.
- The State Water Board should consider including fish surveys beyond the demersal zone in San Francisco Bay and also resuming several key studies that are currently suspended:
  (1) shoreline residential fish survey, which develops data on abundance trends and distribution of many shoreline fishes — including predatory largemouth bass;
  (2) catfish surveys to understand the role of these predators on and competitors with native species; and
  (3) juvenile sturgeon surveys which are necessary for proper management and for restoration planning
- The Department recommends that shallow-water habitats associated with floodplains be sampled more thoroughly to provide a suitable baseline. Information on fishes in shallow-water habitats has been periodically gathered by several special studies, but very limited sampling is on-going. Current beach seine sampling provides reasonable coverage in the lower Sacramento and San Joaquin rivers and some of the Delta, but sampling is sparse in the western Delta and absent in Suisun Bay. Sampling is currently relatively intensive within Liberty Island, but this effort is not planned to be long-term. The Department recommends that some modest level of effort be maintained.

Green and White Sturgeon Monitoring

The Department recommends several actions in the above sections regarding green and white sturgeon that the State Water Board should take into consideration when updating the Bay-Delta Plan and in determining what future monitoring and special studies might be needed.

Steelhead and Chinook Salmon Monitoring

Several new programs have been initiated in recent years that will significantly improve monitoring and contribute to adaptive management of Central Valley Chinook salmon. The Department encourages the State Water Board to consider the following programs during the review and update of the Monitoring and Special Studies Program.

- The State Water Board should support continued implementation of the Central Valley Constant Fractional Monitoring Program. The program was designed to address a number of objectives, summarized below, which are relevant to implementation of the Bay-Delta Plan:
  (1) Evaluate the relative impacts of water project operations on hatchery and naturally-produced Chinook salmon,
  (2) Evaluate the success of restoration actions designed to increase natural production of Central Valley Chinook salmon,
  (3) Evaluate the contribution rates of hatchery fish to Central Valley Chinook salmon populations,
  (4) Evaluate the Central Valley propagation program's genetic and ecological effects on natural Chinook populations,
  (5) Estimate exploitation rates of hatchery and natural Central Valley Chinook salmon in ocean and inland fisheries, and
  (6) Evaluate the recovery of listed stocks of Chinook salmon.
- The State Water Board should support full implementation of the Central Valley Chinook Salmon In-River Escapement Monitoring Plan (Bergman et al. 2012) in order to improve monitoring of adult Chinook salmon returning from the ocean to spawn in Central Valley streams (escapement) and harvested in freshwater. Accurate estimates of escapement are critical to monitoring the recovery of listed stocks and for sound management of ocean and inland harvest.
- The State Water Board should support full implementation of the Comprehensive Monitoring Plan for Steelhead in the California Central Valley (Eilers et al. 2010), the goal of which is to provide the data necessary to assess the restoration and recovery of steelhead populations by determining their distribution, abundance, and trends.
- The State Water Board should support continuation of acoustic tagging studies to enhance our understanding of reach-specific and through Delta survival of juvenile Chinook salmon and steelhead and the relationships between estimated survival rates, flows, exports, and other factors.

Instream Flow Studies

Summary of recommendation

The Department recommends the State Water Board evaluate the current Bay-Delta Plan objectives that have been implemented on tributaries to the Bay-Delta estuary to ensure that they are fully supporting salmonid life stages. These objectives include maintaining water temperatures and dissolved oxygen at levels that will support adult migration, egg incubation, smolting, and early-year and late-year juvenile rearing at levels that facilitate attainment of specified life-history stage production goals (CDFG 2010a). The Department also recommends continuing collaboration between the Department and the State Water Board to develop instream flow recommendations for tributary watersheds upstream of the Bay-Delta estuary.

Supporting information

The Department's Instream Flow Program (IFP) collaborates with the State Water Board to develop flow criteria on tributaries of the Bay-Delta estuary as mandated by Senate Bill 7, the 2009 Delta Reform Act. IFP staff coordinate and work directly with the Division of Water Rights' Public Trust Unit regarding ongoing studies statewide, technical issues concerning study methods, and other instream flow related topics. Public Trust Unit staff routinely join IFP for site visits and field data collection. The Department's IFP develops flow recommendations to address stream habitat issues affecting anadromous salmonids that are linked to flow, including but not limited to stream habitat connectivity, fish passage for different life stages of anadromous fish, and stream temperature. For example, thermal barriers may impede fish passage or terminate adult spring-run Chinook salmon migration. The IFP may use temperature monitoring to develop stream temperature profiles in order to identify thermal barriers and make recommendations for the amount of flow needed to bring temperatures into the range tolerated by salmonids.

The IFP is currently developing flow recommendations to support anadromous salmonids on Sacramento River tributaries including Lower Butte Creek, Mill Creek, Deer Creek, and Battle Creek. The Department is using site specific methodologies to evaluate the flows needed to address key issues identified for these streams such as fish passage and temperature. The IFP, in coordination with the State Water Board, will continue to evaluate and use site specific methodologies and region wide methodologies to develop instream flow recommendations on Sacramento River tributary streams. These recommendations will inform future phases of the State Water Board's Bay-Delta Plan review.

California Water Quality Monitoring Council

The need for enhanced coordination and integration of monitoring and modeling activities to support implementation of the updated Bay-Delta Plan was discussed during Workshop 1 (September 5 and 6, 2012). The California Water Quality Monitoring Council (CWQMC), specifically the work groups formed under its guidance, represents a venue for such efforts.

The CWQMC was formed as a result of a Memorandum of Understanding (MOU) signed by the Secretaries of the Resources Agency and the California Environmental Protection Agency, as mandated by the Senate Bill 1070. The MOU and Senate Bill 1070 (Water Code Sections 13167 and 13181) require that the CWQMC develop specific recommendations to improve the coordination and cost-effectiveness of water quality and ecosystem monitoring and assessment, enhance integration of monitoring data across departments and agencies, and increase public accessibility to monitoring data and assessment information. A key recommendation of the CWQMC (2008) is to provide a platform for intuitive, streamlined access to water quality and ecosystem information that directly addresses users' questions and decision-making needs.

Under the overarching guidance of the CWQMC, theme-specific workgroups (e.g., California Estuary Monitoring Workgroup) evaluate relevant existing monitoring, assessment, and reporting processes and work to enhance those efforts so as to improve the delivery of water quality and ecosystem health information to the user (e.g., policy makers), in the form of theme-based internet portals. Each of the workgroups formed under the ―Are our aquatic ecosystems healthy?‖ theme are potentially relevant to aspects of the monitoring infrastructure in place or likely to be developed to address questions regarding pelagic and anadromous fish species of relevance to the Bay-Delta Plan. These include the California Estuary Monitoring Workgroup, Healthy Streams Partnership (streams and rivers), and California Wetland Monitoring Workgroup. These workgroups serve as a venue for the types of enhanced coordination, integration, assessment and reporting of on-going and potential future monitoring efforts discussed during Workshop 1 (September 5 and 6, 2012).

References

Ayers and Associates. 2001. Two-dimensional modeling and analysis of spawning bed mobilization, Lower American River. Prepared for the U.S. Army Corps of Engineers, Sacramento District Office.

Baker, P.F., T.P. Speed, and F.K. Ligon. 1995. Estimating the influence of temperature on the survival of Chinook salmon smolts (*Oncorhynchus tshawytscha*) migrating through the Sacramento-San Joaquin River Delta of California. Canadian Journal of Fisheries and Aquatic Sciences 52:855-863.

Bergman, J. M., R. M. Nielson, and A. Low. 2012. Central Valley in-river Chinook salmon escapement monitoring plan. Fisheries Branch Admin. Report No. 2012-01, California Department of Fish and Game. Sacramento, CA. January 2012. Available on-line at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=42213

Brandes, P.L. and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: R.L. Brown, editor, Contributions to the biology of Central Valley salmonids. Volume 2. California Department of Fish and Game Fish Bulletin 179:39-136.

Burau, J., A. Blake, and R. Perry. 2007. Sacramento/San Joaquin River Delta regional salmon outmigration study plan: Developing understanding for management and restoration. December 10, 2007. Available on-line at: http://www.science.calwater.ca.gov/pdf/workshops/workshop_outmigration_reg_study_plan_011608.pdf

CDFG. 1998. Report to the Fish and Game Commission: A status review of the spring-run Chinook salmon in the Sacramento River drainage. Candidate species status report 98-1. California Department of Fish and Game. Sacramento, CA. June. Available on-line at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3518

CDFG. 2009. California Endangered Species Act Incidental Take Permit No. 2081-2009-001-03. Department of Water Resources California State Water Project Delta Facilities and Operations. California Department of Fish and Game, Bay-Delta Region. Yountville, CA. February 23.

CDFG. 2010a. Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta. California Department of Fish and Game, Water Branch. Sacramento, CA. November 23, 2010.

CDFG. 2010b. Exhibit 1,―Effects of Delta Inflow and Outflow on Several Native, Recreational and Commercial Species‖. California Department of Fish and Game, Bay-Delta Region. Stockton, CA. February 2010.

CDFG. 2010c. Exhibit 3. Flows needed in the Delta to Restore Anadromous Salmonid Passage from the San Joaquin River at Vernalis to Chipps Island. California Department of Fish and Game. February 2010. Available on-line at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/dfg/dfg_exh3.pdf

CDFG. 2011. Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions. July 2011 Draft. California Department of Fish and Game. Sacramento, CA.

CDFG. 2012a. Comments on the Supplemental Notice of Preparation and Notice of Scoping Meeting for Environmental Documentation for the Update and Implementation of the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: Comprehensive Review. California Department of Fish and Game. May 2, 2012.

CDFG. 2012b. Written Information Responsive to the Workshop Questions for the Bay-Delta Workshop 1 – Ecosystem Changes and the Low Salinity Zone. California Department of Fish and Game. August 16, 2012.

CHSRG. 2012. California Hatchery Review Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. California Hatchery Scientific Review Group. June 2012. Available on-line at: http://cahatcheryreview.com/wp-content/uploads/2012/08/CA%20Hatchery%20Review%20Report%20Final%207-31-12.pdf

Cloern, J.E., N. Knowles, L.R. Brown, D. Cayan, M.D. Dettinger, T.L. Morgan, D.H. Schoellhamer, M.T. Stacey, M. van der Wegen, R.W. Wagner, and A.D. Jassby. 2011. Projected evolution of California's San Francisco Bay-Delta-River system in a century of climate change. PLoS ONE 6 (9).

CWQMC. 2008. Maximizing the efficiency and effectiveness of water quality data collection and dissemination. Submitted to Linda S. Adams, Secretary for Environmental Protection and Mike Chrisman, Secretary for Resources. California Water Quality Monitoring Council. December 1, 2008.

Delta Stewardship Council. 2012. Final Staff Draft of the Delta Plan. Appendix A: Adaptive Management and the Delta Plan. Available online: http://deltacouncil.ca.gov/delta-plan

Department of Water Resources. 2012. 2012 Central Valley Flood Protection Plan (CVFPP). FloodSAFE California. June 2012

DuBois, J., M. Gingras, G. Aasen. 2011a. Status and Trends of San Francisco Estuary White Sturgeon. Interagency Ecological Program for the San Francisco Estuary Newsletter 24(1): 50-55.

DuBois, J., T. Matt, and T. MacColl. 2011b. 2010 Sturgeon Fishing Report Card: Preliminary Data Report. California Department of Fish and Game, Bay Delta Region.

Eilers, C.D., J. Bergman, and R. Nielson. 2010. A Comprehensive Plan for Steelhead in the California Central Valley. Administrative Report Number: 2010-2. California Department of Fish and Game, Fisheries Branch. October 2012.

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2011. Modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. Estuaries and Coasts 34:120–128.

Grossinger R. and L. Grenier. 2011. Management Tools for Landscape-Scale Restoration of Ecological Functions in the Delta. Aquatic Science Center. March 1, 2011.

Horn, M.J. and A. Blake. 2004. Acoustic tracking of juvenile Chinook salmon movement in the vicinity of the Delta Cross Channel. 2001 Study results. U.S. Department of the Interior. Technical Memorandum No. 8220-04-04.

Israel, J.A. and A.P. Klimley. 2008. Life history conceptual model for North American green sturgeon (Acipenser medirostris). California Department of Fish and Game, Delta Regional Ecosystem Restoration and Implementation Program.

Kjelson, M.A. and P.L. Brandes. 1989. The use of smolt estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin Rivers, California. Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105. p.100-115.

Kormos, B., M. Palmer-Zwahlen, and A. Low. 2012. Recovery of coded-wire tags from Chinook salmon in California's Central Valley escapement and ocean harvest in 2010. Fisheries Branch Admin. Report No. 2012-02. March 2012. Available on-line at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44306

Low, A.F., J. White, and E. Chappell. 2006. Relationship of Delta Cross Channel Gate operations to loss of juvenile winter-run Chinook salmon at the CVP/SWP Delta facilities. November 2006. Available on-line at: http://www.science.calwater.ca.gov/pdf/ewa/EWA_delta_cross_channel_closures_06_111406.pdf

McGill, Jr. R.R. 1979. Land Use Changes in the Sacramento River Riparian Zone, Redding to Colusa, An Update – 1972 to 1977. Department of Water Resources, Northern District.

Morgan, T. L. 2005. Hydrological and physiological factors controlling Fremont cottonwood seedling establishment along the Sacramento River, California: surface and alluvial groundwater relations, ecophysiological analysis from 2002-2004 field seasons, and cottonwood water use determination using stable isotope analysis. Master's thesis. California State University, Chico.

Morgan, T. L., and A. Henderson. 2005. Cottonwood seedling monitoring during 2004 and 2005 along the Sacramento River, California. 30 December. Memorandum draft report for California Department of Water Resources, Northern District.

Moyle, P. B. 2002. Inland Fishes of California, 2nd edition. University of California Press, Berkeley,CA

National Research Council. 2012. Sustainable Water and Environmental Management in the California Bay-Delta. The National Academies Press, Washington, D.C., Prepublication Available online at: http://www.nap.edu/catalog.php?record_id=13394. Accessed 8/10/2012.

Newman, K.B. 2008. An evaluation of four Sacramento-San Joaquin River Delta juvenile salmon studies. Prepared for CALFed Science Program. Project No. SCI-06-G06-299. March 31. United State Fish and Wildlife Service. March 31, 2008. Available online at: http://www.science.calwater.ca.gov/pdf/psp/PSP_2004_final/PSP_CalFed_FWS_salmon_studies_final_033108.pdf

NMFS. 2009a. Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project and State Water Project. June 4, 2009. National Marine Fisheries Service, Southwest Region. Available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_exh3.pdf

NMFS. 2009b. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. National Marine Fisheries Service.

Olsen, D., R. Revnak, and P. Bratcher. 2012. Redd Dewatering, AFRP-N02-10 Upper Sacramento River Pilot Study Year 2: November 30, 2011 to March 16, 2012. Central Valley Project Improvement Act – Anadromous Fish Restoration Program. August 2012.

Perry, R.W. and J.R. Skalski. 2008. Migration and survival of juvenile Chinook salmon through the Sacramento-San Joaquin River Delta during the winter of 2006-2007. Report prepared for the U.S. Fish and Wildlife Service. September 2008.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. I. Prestergaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47: 769-784.

Richter, B.D., R. Mathews, D.L. Harrison, and R. Wigington. 2003. Ecologically sustainable water management: managing river flows for ecological integrity. Ecological Applications 13:206-224.

Sommer, T. R., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001a. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26:6–16.

Sommer T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001b. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325–333.

Sommer, T. R., W. C. Harrell, and M. L. Nobriga. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25:1493-1504.

State Water Resources Control Board. 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, 95-1WR. May 1995. Sacramento, CA.

Stella, J. C. 2005. A field-calibrated model of pioneer riparian tree recruitment for the San Joaquin basin, California. Doctoral dissertation. University of California, Berkeley.

Stillwater Sciences. 2006. Restoring cottonwood & willow riparian forests; a field-calibrated seedling recruitment model for the lower San Joaquin Basin. Brochure.

The Nature Conservancy. 2003. Management and monitoring recommendations for floodplain habitats of the Chico Landing Subreach (RM 178-206), Sacramento River, California. The Nature Conservancy. February 28, 2003. Chico, CA.

The Nature Conservancy, Stillwater Sciences and ESSA Technologies. 2008. Sacramento River Ecological Flows Study: Final Report. Prepared for CALFED Ecosystem Restoration Program. Sacramento, CA. 72 pp.

The Resources Agency. 1989. Upper Sacramento River, Fisheries and Riparian Habitat Management Plan. January 1989.

USBR. 2011. SECURE Water Act, Section 9503(c) – Reclamation Climate Change and Water. U.S. Department of Interior, Policy and Administration, U.S. Bureau of Reclamation. Denver, CO. April 2011. Available at: http://www.usbr.gov/climate/SECURE/docs/SECUREWaterReport.pdf. Accessed 9/11/2012.

USFWS. 2001. Abundance and survival of juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary: 1997 and 1998 Annual progress reports. U.S. Fish and Wildlife Service.

USFWS. 2003. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary: 1999 Annual progress report. U.S. Fish and Wildlife Service.

USFWS. 2006. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary: 2000 Annual progress report. U.S. Fish and Wildlife Service.

USFWS. 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP), Biological Opinion - Delta Smelt. U.S. Fish and Wildlife Service. Available at: http://www.fws.gov/sfbaydelta/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf

USFWS. 2012. CHINOOKPROD database. Anadromous Fish Restoration Program. U.S. Fish and Wildlife Service. Lodi, CA.

Vogel, D.A. 2008. Pilot study to evaluate acoustic-tagged juvenile Chinook salmon smolt migration in the Northern Sacramento-San Joaquin Delta 2006-2007. Report prepared for the California Department of Water Resources, Bay/Delta Office. Natural Resource Scientists, Inc. March.

Whipple A.A., Grossinger R.M., Rankin D., Stanford B., Askevold R.A. 2012. Sacramento-San Joaquin delta historical ecology investigation: exploring pattern and process. Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. a report of SFEI-ASC's Historical Ecology Program, SFEI-ASC Publication #672, San Francisco Estuary Institute-Aquatic Science Center, Richmond, Ca.